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Single Phase to Three Phase MOSFET based Inverter

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Abstract - *Most of the induction motors required in industries today are working on three-phase source of alternating voltage. Three Phase A.C. supplies are not available for all the time, particularly in Rural Area. So a new scheme of Single Phase to Three Phase Inverter using MOSFET is proposed. A PWM technique is used to have a variable frequency A.C. Induction Motors. It also gives a variable speed control which deals with considerable savings in Energy and reduces cost of Electricity.*

Use of dedicated pulse generator (Microcontroller) IC HEF 4752 made by PHILLIPS for PWM generation and MOSFET IRF 840 is used for switching purpose to enhances the performance of the inverter. It generates six pulses required for three phase supply. The phase angle is programmed to 120 degree. The output of opto isolator is given to Darlington pair of transistors for amplification of current and voltage.

A case study of kitchen ventilation system in a hotel shows that it can save energy up to 18%. Thus system can become more useful in today's problem of energy crisis.

Key Words: *Frequency controlled induction motor drive P.W.M. inverter concepts*

1.INTRODUCTION

1.1 Need for single Phase to Three Phase Inverter

Nowadays electric supply is one of the basic needs but because of surrounding environmental conditions and practical limitations the generation of electricity is insufficient hence to fulfill the electricity requirement load shedding is executed, but it is not satisfying the complete requirement so inverter is used to obtain ac supply from a battery.

In industries three phase appliances are frequently used due to their advantages over single phase power supply. If we go to have a three phase inverter which is available in the market, cost factor comes in to the picture. So we have made an attempt made to have "Single Phase to Three Phase MOSFET Based Inverter", which can save money up to great extent.

This paper makes an attempt to demonstrate a variable frequency control of three phase induction motor using PWM technique, to control the speed of a three phase induction motor.[1]

We aim to design and implement a variable frequency drive for three phase induction motor using PWM control technique for a three phase MOSFET based Inverter

1.2 Principle of Operation

1) To vary motor speed, we vary stator supply frequency 'f' because

2) Synchronous Speed = Ns = 120f / P.

Where P = no. of poles of Induction Motor

To achieve maximum torque we need to keep air gap flux constant .This is done by keeping the voltage to frequency ratio constant i.e. Vs / f = constant

1.3 Frequency controlled induction motor drive

This method involves changing synchronous speed by changing frequency of a.c. supply to induction motor to cause speed variation, as the true speed of the motor is very close to synchronous speed. Either voltage source inverters or current source inverters may be used.

2. P.W.M. INVERTER CONCEPTS

PWM is the method is used for switching devices to produce the effect of continuously changing analog signals. This PWM conversion has a very high electrical efficiency. In controlling either a 3 phase synchronous motor or a 3phase induction motor, it is required to receive a perfectly sinusoidal current waveform in motor windings, with relative phase displacements of 120^0. The generation of sine wave power via a linear amplifier system is having low efficiency, up to 64%. If without using linear circuitry, fast electronic switching devices are preferred, and then the efficiency becomes greater than 95%, as per the characteristics of the semiconductor power switch.[2]

Modulation of the duty ratio decides shape of Load current waveform. If the duty ratio is changing in time, then the current in an inductive load has nature of a sine wave at the modulation frequency, carrying ripple frequency .The IC HEF4752V for the A.C. motor control uses this particular method. The 1 kHz technique using SCR is highly useful for shaft output powers of more than a few kW.[3]

However, using MOSFETS with switching times less than 1 µsec, the carrier frequency increases to the 20 kHz or more.[5]

To avoid any D.C. in motor, and hence to avoid parasitic torque, a digital waveform generation technique should be used. As regards to micro-processor /micro-computer implementation ,the waveform is stored as a 'look-up' table of numbers corresponding to the sine wave .To generate the 3 phases, this can be read such that the correct 120° phase relationship is maintained. The numbers from the table

corresponds to the duty ratios of 100 % modulation: these numbers are changed by multiplication or other technique to give the correct duty-ratio numbers for the modulation index desired. the speed of the motor is varied with rate at which the reading pointers read the look-up table .If the pointers are steady, then the system is 'frozen' at specific point on the 3 phase sine wave waveform, generating static torque from a synchronous motor at a null speed. The rate at which the numbers are produced by this scanning method of the look-up table is constant and gives the carrier frequency. For conversion of 3 simultaneous digits to pulses, three digital counters are required. The counters are designed to have double-aged modulation. We have used a dedicated embedded IC HEF 4752V SPWM pulse generator designed by PHILIPS Semiconductors for AC motor control.[4]

The line to-line voltage across the load will have ripple frequency of twice the switching frequency, and will have a spectrum of even harmonics and no other components below twice the switching frequency. Motor ripple current becomes low and motor losses are decreased.

3. BLOCK DIAGRAM

3.1 Control Circuit Description

- The CMOS based HEF4752V PWM Pulse Generator IC is important part of control circuit. This IC produces 3 types of 120° out of phase signals that are Pulse Width Modulated sinusoidal waveforms. It is provide with four clock signals. FCT (Frequency Clock)
- VCT (Voltage Clock)
- RCT (Reference Clock)
- OCT (Output Delay Clock)

The FCT is a Frequency Clock generated by Voltage Controlled Oscillator (VCO) based on IC NE566. The FCT operates at about 700 KHz and is used to control the output frequency of the output signal between 0-200Hz. The VCT, OCT and RCT Signals are generated by the SN74LS14 Hex Schmitt Trigger and are set to operate at 400 KHz each. A BA159 (fast switching rectifier) diode based negative clipper circuit is used to clip off the negative part of the VCO output. To boost up the voltage a 2N2369 transistor is used.

3.2 Signal Amplifier and Driver Circuit

Opto-isolators electrically isolate the control circuit from the power circuit and protect the control circuit .The FCT is a Frequency Clock generated by Voltage Controlled Oscillator (VCO) based on IC NE566. The FCT operates at about 700 KHz and is used to control the output frequency of the output signal between 0-200Hz. Next, we use Darlington pair transistors circuits after each isolator to boost current to trigger the Power MOSFET without loading on the opto-isolators. The outputs of the Darlington pairs are given to the Power MOSFET switches for proper operation of the inverter.

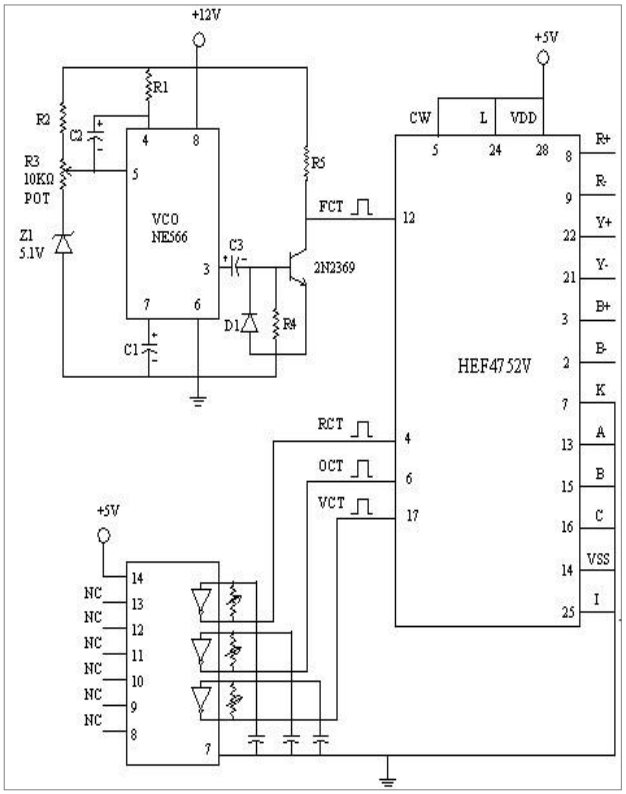


Fig- 3.1 Control Circuit

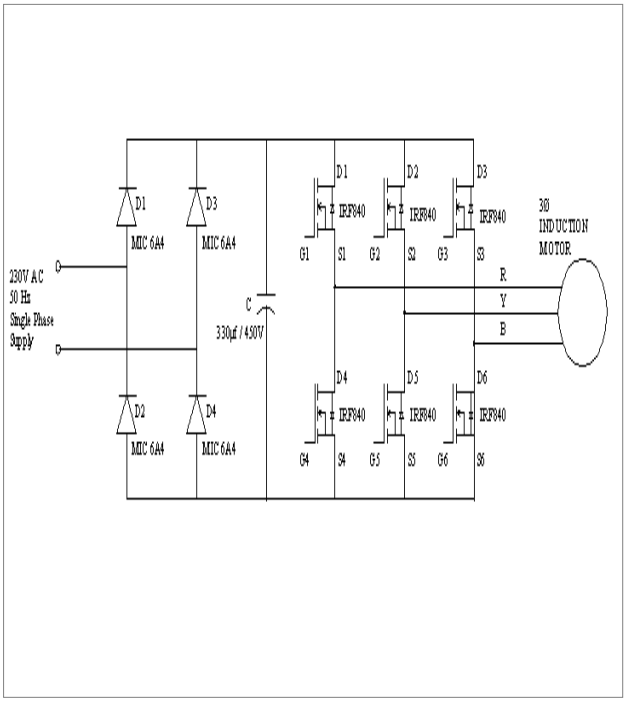


Fig- 3.2 Power Inverter Circuit

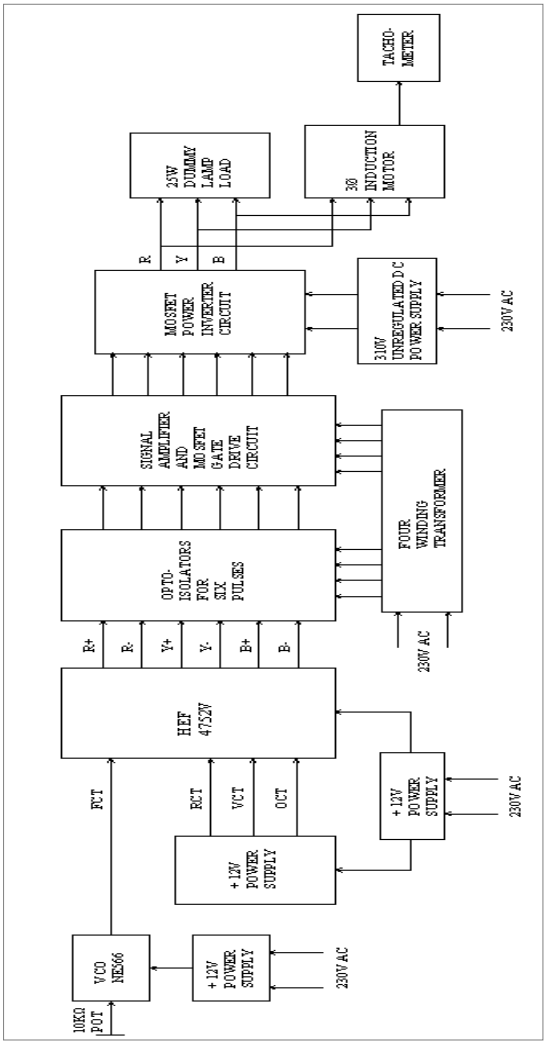


Fig- 3.3 Block diagram of Single Phase to Three Phase MOSFET Inverter

3.3 Four Winding Transformer

A four winding transformer consist of one primary and four secondary windings namely S1,S2,S3,S4.The specification for the secondary windings are of 0-12V and 150mA respectively. The fourth one is having current rating of 450mA.

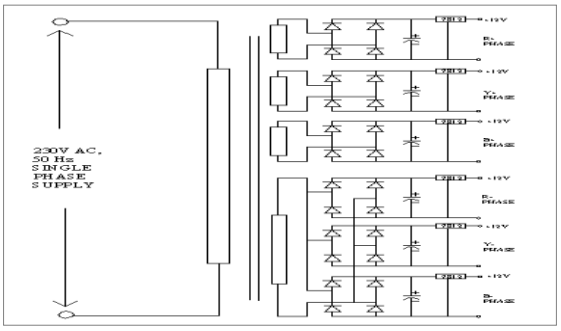


Fig- 3.4 Four Winding Transformer

3.4 . PWM Voltage Source Inverter

A PWM inverter is used for varying the voltage and frequency of 3 phase supply as shown in figure 3.4.A single phase supply is rectified to produced DC supply for MOSFETs.[6]

The switching frequency of MOSFET is kept high.The free wheeling diodes are connected across anti parallel MOSFET.A MOSFET and diodes conducts at the same time while carrying the current through load.The 120^0 relationship is maintained through 3 phase.The time period is varied which intern changes the switching time of MOSFETs generating different amplitude and frequency waveforms. The voltage to frequency is obtained with accurate control by the dedicated PWM IC HEF4752V .The line voltage obtained at motor terminal is equal to that of single phase AC Supply voltage.

The applications for PWM AC motor control generally used the switching frequency of 1KHz to 20KHz .This reduces noise and interference due to radio frequency. The power MOSFET are showing greater advantage over bipolar devices w.r.t lower switching time.

Due to low switching time it gives good overload capacity and there is no need of snubber circuits. The power MOSFETs are operated in parallel higher system circuits because it has positive temperature coefficient of resistance.

3.4.1 D.C. supply to inverter

The D.C. supply is taken from rectified single phase AC supply. Inverter isolates AC circuits and DC circuits . This finds useful application in battery operated electrical vehicles.

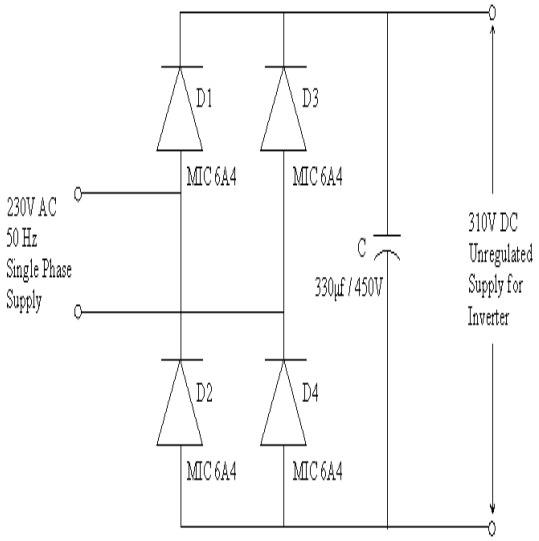
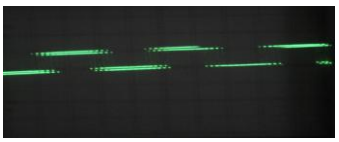


Figure 3.5 Unregulated Power Supply

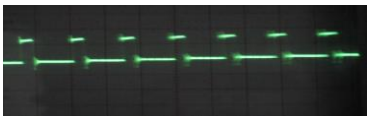
A full bridge rectification is done to get DC supply with ripple voltage. The DC voltage is obtained about 300V,which is acting as input to the inverter.

3. TEST AND RESULTS

The R,Y,B output of PWM IC HEF 4752Vis as follows:



The RCT, OCT & VCT Control Pulses are observed as



R, Y, B-phase output of inverter with respect to neutral are as

Applications:

- Any type of flow control in chemical plant.
- Water flow control.
- In spinning and turning jobs.
- Sugar industries.
- Dairy milk products industries.
- Bakery industry
- Hotel industry

CONCLUSIONS

Thus this circuit provides up to 15% savings in Energy consumed because it can vary the speed as per requirement of the user. This scheme is also advantageous to user to drive a three phase motor when only single phase supply is available, specially in rural area.

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BIOGRAPHIES

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